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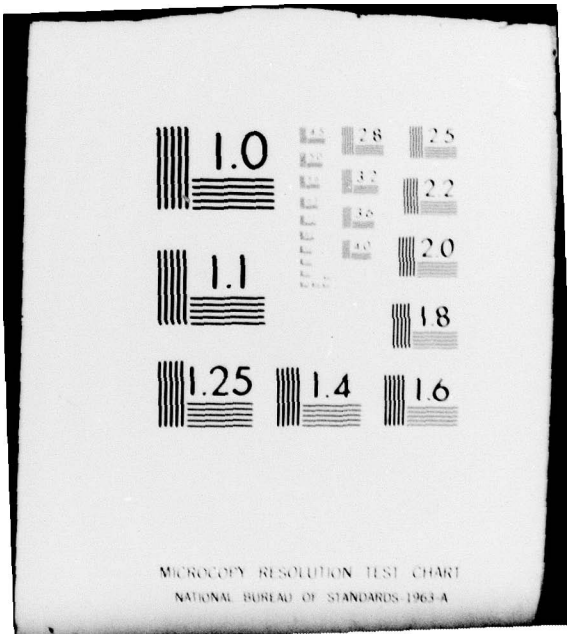
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The flow behavior of five elastomeric impression materials was determined by extrusion viscometry. Initial viscosity ranged from 400 to 5,100 poise at a shear rate of 2.2 reciprocal seconds. All of the elastomers showed initial non-Newtonian behavior and increased viscosity with time.

The data suggest that clinical impression making procedures should be tailored to produce rates of shear commensurate with those required to optomize the flow properties of modern impression materials.

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APPARENT VISCOSITIES OF SETTING ELASTOMERS

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Commercial materials and equipment are identified in this report to specify the experimental procedure. Such identification does not imply official recommendation or endorsement or that the equipment and materials are necessarily the best available for the purpose.

Synopsis

The flow behavior of five elastomeric impression materials was determined by extrusion viscometry. Initial viscosity ranged from 400 to 5,100 poise at a shear rate of 2.2 reciprocal seconds. All of the elastomers showed initial non-Newtonian behavior and increased viscosity with time.

APPARENT VISCOSITIES OF SETTING ELASTOMERS

The indirect fabrication of well fitting dental prostheses requires the accurate counterreplication of oral structures by impression materials. Accurate counterreplication, in turn, is dependent upon the ability of a material to flow into the intricate irregularities that characterize the surfaces of teeth and soft tissues.

Previous studies have addressed the rheological (flow) characteristics of impression compound, alginate, polysulfide and silicone impression materials.[1-3] Also, a more recent investigation[4] has dealt with flow behavior of the unmixed components of several dental impression products. The availability of new materials has suggested the need for further comparative assessment of the flow characteristics of dental elastomers.

The present investigation was conducted to examine the rheological behavior of five elastomeric impression materials as a function of time and shear rate.

Materials and Methods

Test products included two silicones,* two polysulfides,+ and a polyether.# The base catalyst components of each material were dispensed

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* Material A, Xantopren Blue, Unitek Corporation, Monrovia, CA 91016 and Material B, President Light Body Impression Material, Coltene AG, Alstätten, Switzerland.

\+ Material C, Accralastic, Material D, Light Body Permlastic, Kerr Sybron Corporation, Romulus, MI 48174.

\# Material E, Polyjel, The L. D. Caulk Company, Milford, DE 19963.

by weight and mixed in accordance with the respective manufacturer's instructions. Proportioning and mixing were accomplished at 23±2C.

The viscosities of the test materials were determined by an extrusion technique. The instrumentation and relevent technology have been described elsewhere.[5] Specifically, however, the mixed components of each material were extruded through a 0.042-inch capillary with the use of a constant strain-rate testing machine at crosshead speeds of 0.02, 0.05, 0.10, and 0.20-inch per minute. The load required for extrusion of each material at each crosshead speed was measured as a function of time. Initial load-time relationships were established at one minute after the termination of mixing. Data were recorded for an additional three-minute period. Five trials were conducted with each material at each crosshead speed. Recorded data were transformed into the rheological quantities of shear stress and shear rate to allow calculation of the viscosity of each material as a function of time and shear rate.

Results

The selected crosshead speeds produced shear rates ranging from 0.89 to 8.9 reciprocal seconds (sec^{-1}).

The changes in viscosity with time at a shear rate of 2.2 sec^{-1} are shown in Figures 1 and 2. Initial viscosities were: A, 400 poise; D, 500 poise; B, 1,400 poise; 2,300 poise; and E, 5,100 poise. The viscosity of the polysulfides (Materials C and D) increased gradually over the three-minute period of measurement. Viscosity values for both products at four minutes after the end of mixing were about twice those observed initally. Viscosity-time behavior of the other materials was

characterized by an abrupt increase in viscosity at 84 seconds (Material A); 96 seconds (Material B) and 156 seconds (Material E) after the end of mixing.

The effect of shear rate on one-minute-old base-catalyst mixtures of the test products is shown in Figure 3. The viscosity of four materials decreased markedly with increasing rates of shear. Respective viscosity values for Materials C and D at 8.9 sec^{-1} were 50 percent and 85 percent less than those observed at 0.89 sec^{-1}. The viscosities of Materials B and E exhibited reductions of about 70 percent. Material A showed a 260 percent increase in initial viscosity over the range of shear rates employed.

Discussion

The viscosity of a setting elastomer is affected by several factors. It is likely that molecular weight and molecular weight distribution of the organic matter, filler content, base-catlyst ratio and polymerization rate contribute to the time-dependent behavior of elastomeric impression materials. The wide range of initial viscosities exhibited by the test materials may be a reflection of pronounced compositional differences. Also, it would appear that the upper limit of the working time range of certain setting elastomers is delineated by their abrupt increase in viscosity.

The pseudoplastic behavior (shear thinning) shown by four of the test materials suggests that rapid spatulation, high rates of extrusion through a syringe nozzle and abrupt seating of the clinical impression

tray may improve the ability of these substances to flow into the minute surface interstices of the oral structures.

The apparent dilatancy (shear thickening behavior) exhibited by Material A may be the result of continued mixing of the base paste and liquid catalyst. At high rates of shear, the forces required for extrusion of the material may provoke additional base-catalyst interaction and a subsequent increase in polymerization rate. During the impression making procedure, the prospect for the premature development of elastic properties would appear to be greater for a dilatant material than for a pseudoplastic substance. It follows that distortion of a material of the former type may occur upon its removal from the mouth. Presently, however, the extent to which shear thickening might limit the range of application of an impression material is uncertain and remains to be studied.

Conclusions

More than a tenfold difference in the initial viscosities of five elastomeric impression materials was demonstrated by extrusion viscometry. All of the materials exhibited increased viscosity with time. However, the viscosities of two materials increased at a markedly faster rate.

The rheological behavior of four test products was characterized by a decrease in initial viscosity with increasing rates of shear. The flow of such materials into the surface irregularities of hard and soft oral structures may be enhanced by their deposition at high rates of shear.

The data suggest that clinical impression making procedures should be tailored to produce rates of shear commensurate with those required to optimize the flow properties of modern impression materials.

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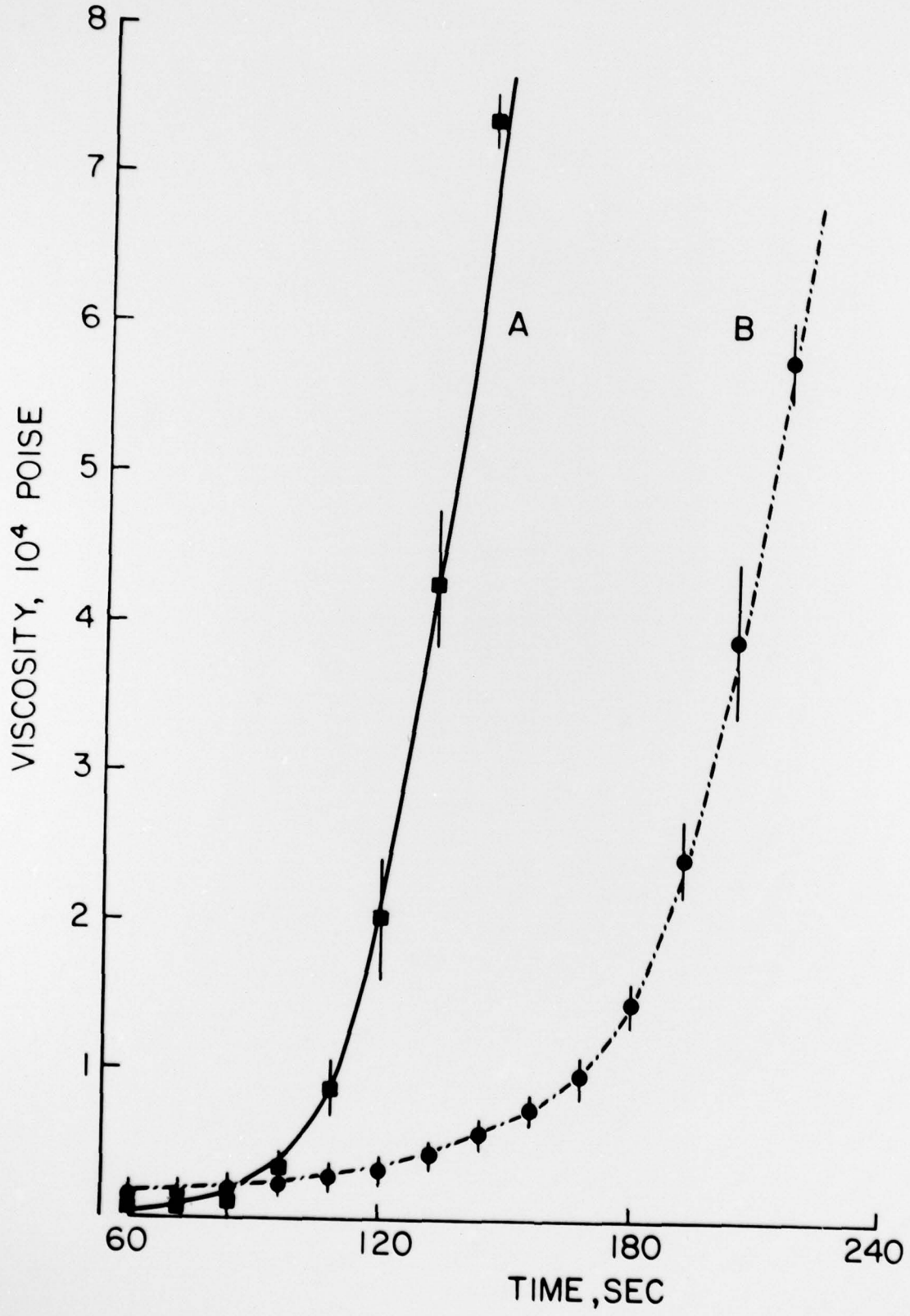
Legends for Figures

Figure 1. Viscosity of two impression materials as a function of time at a shear rate of 2.2 reciprocal seconds.

Figure 2. Viscosity of three impression materials as a function of time at a shear rate of 2.2 reciprocal seconds

Figure 3. Viscosity of impression materials as a function of shear rate one minute after the end of mixing.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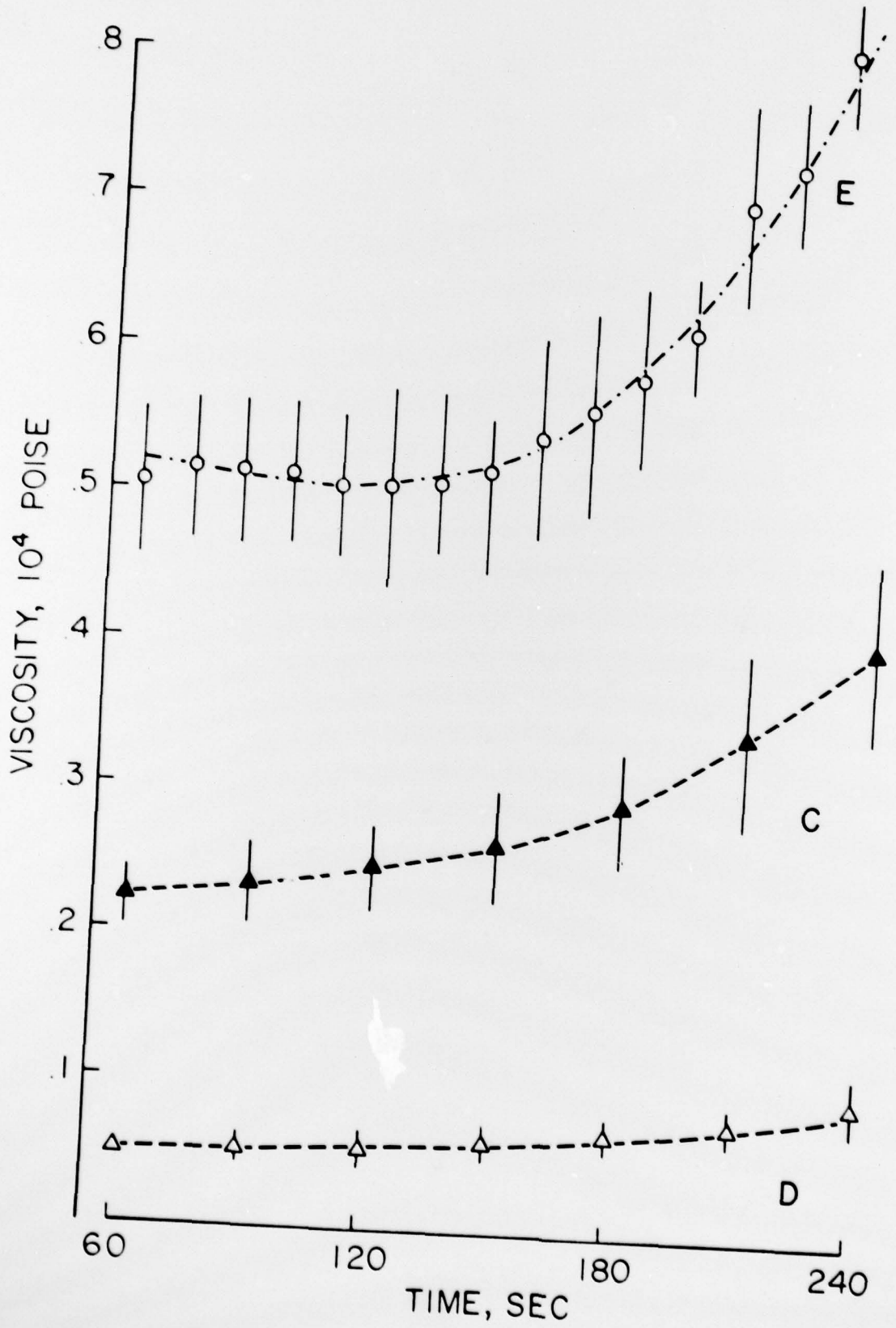
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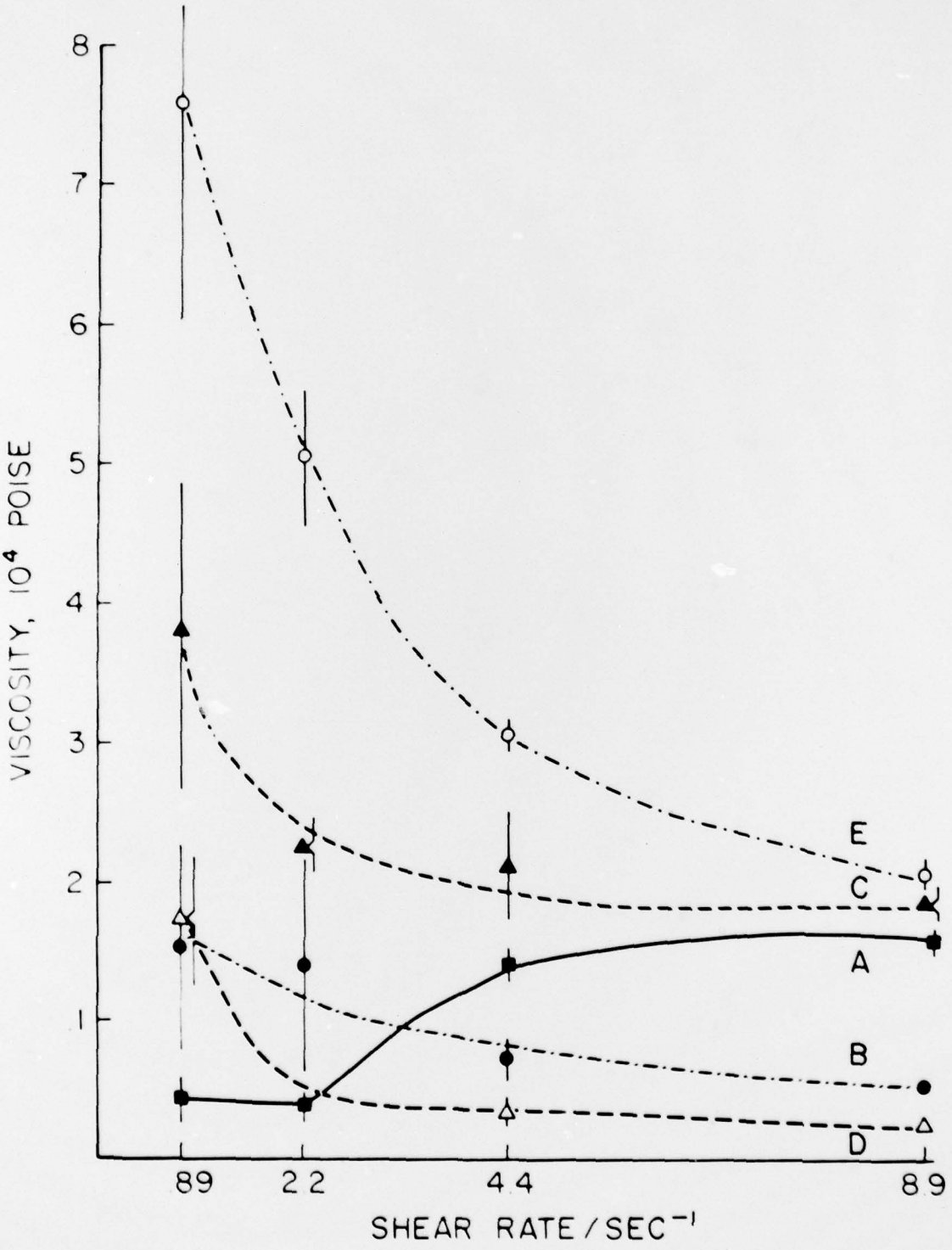
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